WOODY SPECIES RICHNESS AND ABUNDANCE IN A TROPICAL SAVANNA OF NORTHERN GHANA

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ABSTRACT

The floristic composition and abundance of woody plants in a tropical savanna were studied at the Damongo Scarp of Northern Ghana. The purpose of the study was to identify the woody species and determine their abundance and densities in the study area. Ten nested square vegetation plots of 15 m × 15 m were used. Tree and shrub species were identified based on their physiognomic characteristics. A total of 693 trees belonging to 50 species, 41 genera and 20 families were recorded. Also 185 shrubs were identified belonging to 11 species, 10 genera and 8 families. Densities of 69.3 trees and 18.5 shrubs per 100 m^2 were established. The assessment revealed that the characteristics of the vegetation in the Scarp were generally similar to that of other guinea savanna areas. It has also revealed that the floristic composition (species richness) and abundance of woody species at different areas of the guinea savanna zone are unique.

KEY WORDS: Woody plants, species abundance, Guinea savanna, Damongo Scarp, Ghana

RÉSUMÉ

La composition et l'abondance floristiques des plantes ligneuses dans une savane tropicale ont été étudiées dans l'escarpement de Damongo du Ghana nordique. Le but de l'étude était d'identifier les espèces ligneuses aussi que de déterminer leur abondance et densité dans le secteur d'étude. Dix parcelles nichées de terrain de végétation de prélèvement de 15 m × 15 m ont été employées. Les espèces d'arbres et d'arbustes ont été identifiées en se basant sur leurs caractéristiques physionomiques. Au total on enregistré un numéro de 693 arbres appartenant à 50 espèces, à 41 genres et à 20 familles. De la même manière, un total de 185 arbustes ont été identifiés, appartenant à 11 espèces, à 10 genres et à 8 familles de végétation. La densité a été établie à 69.3 arbres et 18.5 arbustes par 100 m^2. L'évaluation a indiqué que les caractéristiques de la végétation dans l'escarpement étaient généralement analogues à celles dans les autres secteurs de la savane de Guinée. Elle a également indiqué que la composition floristique (la richesse de l'espèce) et l'abondance de la varieté ligneuse dans les différents secteurs de la zone de la savane de Guinée est unique.

INTRODUCTION

In Ghana, the savanna vegetation serves as a source of livelihood for about 30% of the population through the provision of economic resources such as *Vitellaria paradoxon* (Shea), *Parkia biglobosa* (Dawadawa), forage and fuelwood (Yaro 2008). Because of intensive farming, fuel wood harvesting and shortened fallow periods between cropping periods, savannas, especially those in Africa, are undergoing rapid changes in vegetation productivity, structure and composition (Jansen 1988; Lewis & Berry 1988). The guinea savanna zone of Ghana is estimated to cover about 60.77% of the country's total land mass and is the most dominant vegetation type (Anonymous 2002). Previous research carried out on the guinea savanna vegetation type of Ghana included Vigne (1936), Taylor (1952), Lawson et al. (1969), Hopkins (1979), Houssain and Hall (1996), Oteng-Yeboah (1996), Asase and Oteng-Yeboah (2007). All lacked an extensive documentation of diversity and abundance of plant species in the different savanna zones. However, a recent study by Asase et al. (2009) included abundance and distribution data of savanna woody species at the Sinsablingbini Forest Reserve, located 20 km from Tamale, the Northern Regional capital.

The Damongo Scarp, unlike Mole National Park and Kenikeni forest, is the smallest reserve in the West Gonja District of Northern Region, Ghana. Some research has been carried out on the major reserves in the district, especially Mole National Park with monitoring programs initiated since the 1960s to the 1970s (Hall & Jenik 1968; Pegg 1969; Jamieson 1972).

Botanical assessments such as floristic composition, diversity and structure studies are vital in the framework of understanding the scope of plant diversity in various ecosystems (WCMC 1992; Addo-Fordjour et al. 2009). They are helpful for the estimation of sustainability of ecosystems since they play a major role in the conservation of plant species and ecosystem management (Tilman 1988; Ssegawa & Nkuutu 2006). Ecological data obtained in this regard are not only valuable for the application of sound management practices, they are also useful in identifying important elements of plant diversity, protecting threatened and economic species, and monitoring the state of vegetations (Tilman 1988; Ssegawa & Nkuutu 2006; Addo-Fordjour et al. 2009).

It is in this light that this research was carried out at the Damongo Scarp to ascertain its woody species' composition and density. Such information is urgently needed to serve as baseline data for management plans that aim at ensuring conservation and sustainable use of savanna vegetation. Specific objectives of this study were: (i) to determine the tree species richness and abundance of the scarp; (ii) to determine the shrub species richness and abundance; and (iii) to determine the regeneration status of trees at the scarp.

STUDY AREA

The study was carried out at the Damongo Scarp (39.36 km²) in the West Gonja District of Northern Region. It is located north of Damongo (Fig. 1) and lies between longitude 1°5' and 2°58'W and latitude 8°32' and 10°2'N. It shares boundaries in the south with Central Gonja District, Bole and Sawla-Tuna-Kalba Districts in the West, Wa East District in the North West, West Mamprusi in the North, and Tolon-Kumbungu District in the East (WGDA 2008). The vegetation is categorized as guinea savanna (Dickson & Benneh 1988). The scarp has high temperatures with the maximum occurring in the dry season. The mean monthly temperature is 27° C. Rainfall is unimodal with an average annual precipitation of about 1144 mm.

METHODS

A total of 10 nested square sampling plots were laid. The first square plot of area 225 m^2 was laid at random and the subsequent plots laid 50 m away from each other. Trees with diameter at breast height (DBH) of 10 cm and above were recorded within the 225 m^2 plots. Smaller squared plots of 100 m^2 were located in the larger plots for the survey of young trees above a height of 1.30 m and below a DBH of 10 cm. Smaller squared plots of 25 m^2 were further located within the 100 m^2 plots for regenerating plants below 30 cm diameter. All individuals in these regeneration plots and subplots were counted by species.

All species of woody plants found rooted within each plot were identified and their individual plants counted. The identification of tree and shrub species was based on their physiognomic characteristics and later confirmed using relevant literature (Hutchinson & Dalziel 1957–1972; Arbonnier 2004; Hawthorne & Jongkind 2006), and by comparison with already identified specimens at the University for Development Studies Herbarium. All botanical nomenclature in this paper follows IPNI (2008).

RESULTS

General Findings

A total of 61 woody species (trees and shrubs) belonging to 51 genera and 21 families were identified in the Damongo Scarp. Fifty (50) tree species belonging to 17 families were identified (Table 1) while 11 shrub species belonging to 8 families were recorded. About 36% of woody species were of the family Leguminosae.

The woody species accumulation, which is the cumulative number of species recorded as a measure of the sampling effort, shows that the majority of woody plants in the scarp were sampled during the study as seen on the curve (Fig. 2) as it reaches the asymptote.

Tree species richness and abundance.—A total of 693 individual trees belonging to 20 plant families, 41

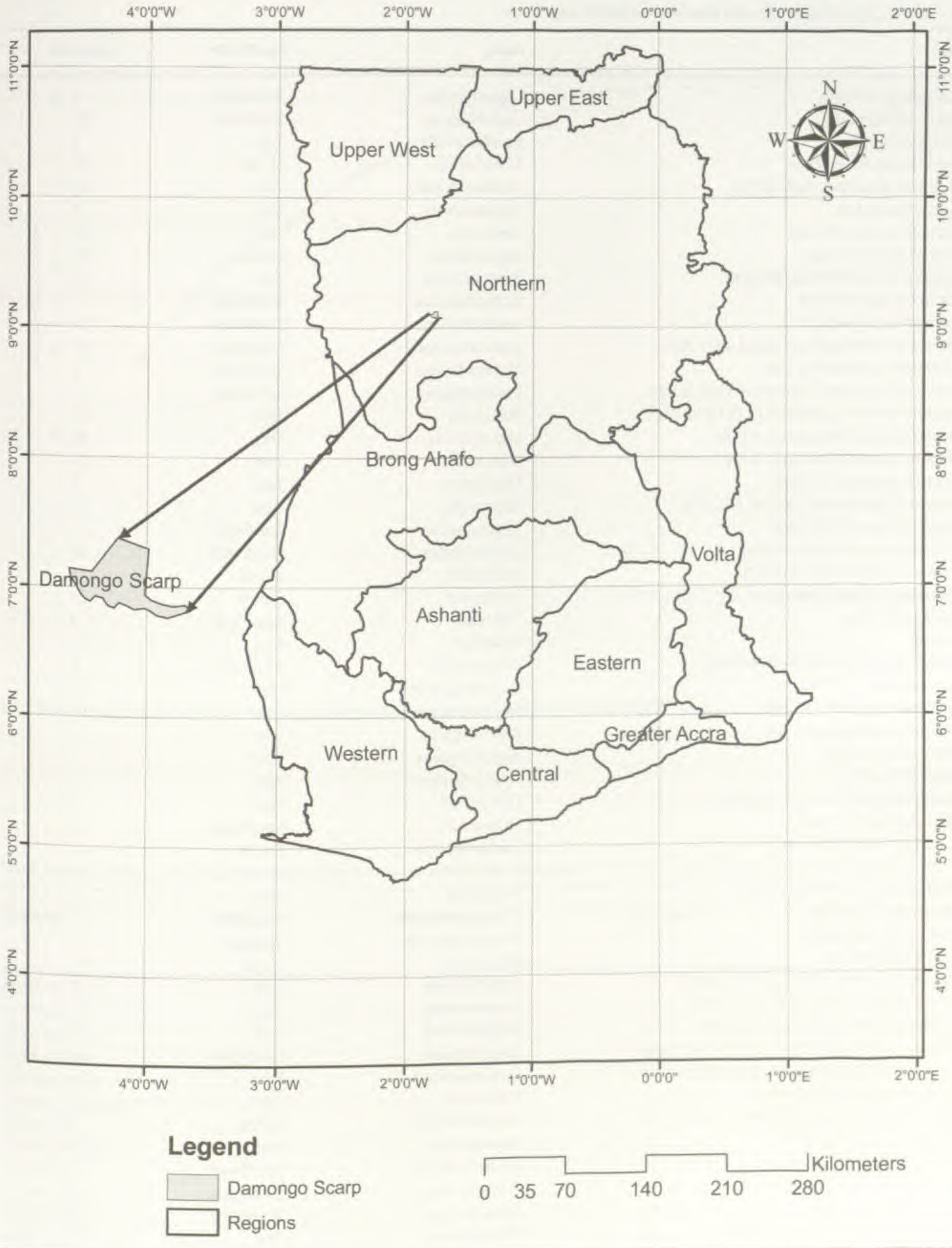

Fig. 1. Map of Ghana indicating the Damongo Scarp.

genera and 50 species were recorded. About 85% (Table 1) of tree species genera consisted of only one species. Genera with two or more species were *Acacia* (2 species), *Combretum* (3 species), *Lannea* (2 species), *Lophira* (2 species), *Strychnos* (2 species) and *Terminalia* (2 species). The most species rich families were Leguminosae (40.8%), Combretaceae (12.1%), Meliaceae (9.9%) and Sapotaceae (7.9%), as illustrated in Table 2.

TABLE 1. Woody species, their families and abundances in the Damongo Scarp.

Species	Family	Growth form	Abundance
Acacia dudgeon Craib.	Leguminosae	Small tree	7
Acacia hockii De Wild.	Leguminosae	Small tree	20
Adansonia digitata L.	Bombacaceae	Tree	9
Annona senegalensis Pers.	Annonaceae	Shrub	24
Anogeissus leiocarpus Guill. & Perr.	Combretaceae	Tree	29
Afzelia africana Sm.	Leguminosae	Tree	4
Azadirachta indica A. Juss.	Meliaceae	Tree	29
Bauhinia rufescens Lam.	Leguminosae	Shrub	10
Bombax costatum Pellegr. & Vuillet	Bombacaceae	Tree	22
Bridelia ferruginea Benth.	Euphorbiaceae	Small tree	7
Burkea africana Hook.	Leguminosae	Small tree	52
Combretum adenogonium Steud. ex A. Rich	Combretaceae	Small tree	31
Combretum comosum G. Don	Combretaceae	Small tree	3
Combretum nigricans Leprieur ex Guill. & Perr.	Combretaceae	Small tree	7
Crossopteryx febrifuga (Afzel. ex G. Don.) Benth.	Rubiaceae	Tree	12
Daniella oliveri (Rolfe) Hutch. & Dalz.	Leguminosae	Tree	40
Detarium microcarpum Guill. & Perr.	Leguminosae	Tree	50
Diospyros gabunensis Gürke	Ebenaceae	Tree	6
Diospyros mespiliformis Hochst. ex. A. DC	Ebenaceae	Tree	13
Entadra Africana Guill & Perr.	Leguminosae	Small tree	7
Erythrophleum africanum Harms	Leguminosae	Small tree	30
Gardenia aqualla Stapf. & Hutch.	Rubiaceae	Shrub	4
Gardenia ternifolia Schumach.	Rubiaceae	Shrub	21
Grewia mollis Juss.	Tiliaceae	Small tree	8
Ficus spp.	Moraceae	Tree	13
Hexalobus monopetalus Engl. & Diels.	Annonaceae	Small tree	3
Hymenocardia acida Tul.	Euphorbiaceae	Tree	10
Isoberlinia doka Craib. & Stapf.	Leguminosae	Tree	20
Kigelia africana (Lam.) Benth.	Bignoniaceae	Tree	3
Lannea acida A. Rich.	Anacardiaceae	Tree	7
Lannea barteri Engl.	Anacardiaceae	Tree	5
Lophira alata Banks ex. C.F. Gaertn.	Ochnaceae	Tree	4
Lophira lanceolata Tiegh.	Ochnaceae	Small tree	23
Macaranga barteri Müll. Arg.	Euphorbiaceae	Shrub	2
Maytenus senegalensis (Lam.) Exell.	Celastraceae	Shrub	6
Mitragyna inermis (Willd.) Kuntze	Rubiaceae	Tree	3
Monotes kerstingii Gilg.	Dipterocarpaceae	Small tree	2
Nauclea diderrichii Merr.	Rubiaceae	Shrub	3
Nauclea latifolia Sm.	Rubiaceae	Shrub	17
Ostryoderris stuhlmannii Dunn ex Baker f.	Leguminosae	Tree	6
Parkia biglobosa (Jacq.) R. Br. ex G. Don	Leguminosae	Tree	17
Parinari curatellifolia Planch. ex Benth.	Leguminosae	Tree	16
Pericopsis laxiflora (Benth. ex. Baker) Meeuwen	Leguminosae	Small tree	4
Piliostigma thonningii (Schumach.) Milne-Redh.	Leguminosae	Tree	14
Pseudocedrela kotschyi Harms	Meliaceae	Tree	16
Pteleopsis suberosa Engl. & Diels	Combretaceae	Shrub	9
Pterocarpus erinaceus Lam.	Leguminosae	Tree	15
Quassia undulata D. Dietr.	Simaroubaceae	Small tree	14
Securidaca longipenduculata Fresen.	Polygalaceae	Small tree	9
Sterculia setigera Delile	Sterculiaceae	Small tree	9
Stereospermum kunthianum Cham.	Bignoniaceae	Tree	13
Strychnos spinosa Lam.	Loganiaceae	Small tree	4
Strychnos innocua Delile	Loganiaceae	Small tree	14
Tamarindus indica L.	Leguminosae	Tree	4
Terminalia avicennioides Guill. & Perr.	Combretaceae	Small tree	41
Terminalia macroptera Guill. & Perr.	Combretaceae	Tree	8
Trichilia emetica Vahl.	Meliaceae	Tree	31
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	Tree	61
Vitex doniana Sweet	Lamiaceae	Small tree	1
Ximenia americana L.	Olacaceae	Shrub	3
Ziziphus mauritiana Lam.	Rhamnaceae	Shrub	3

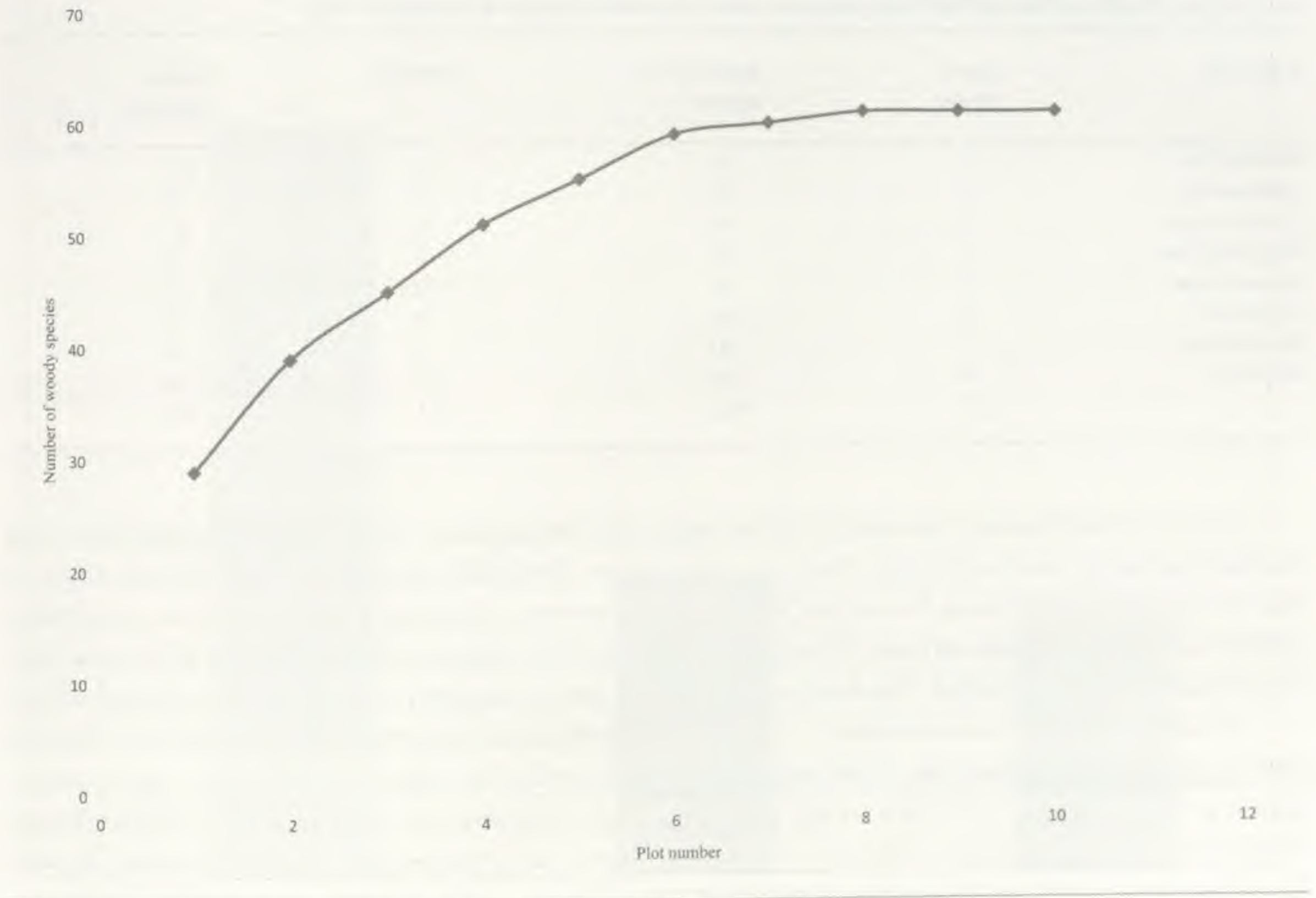

FIG. 2. Woody species accumulation curve indicating the sampling effort in the Damongo Scarp sample.

TABLE 2. Families of trees identified with their respective species richness and relative abundances in the Damongo Scarp.

Tree Family	Species Richness	Relative Species Richness	Abundance	Relative Abundance
Anacardiaceae	2	4	12	1.6
Annonaceae	1	2	3	0.4
Bignonaaceae	2	4	16	2.1
Bombacaceae	2	4	46	6
Combretaceae	6	12	93	12.1
Dipterocarpaceae	1	2	2	0.3
Ebenaceae	2	4	19	2.5
Euphorbiaceae	2	4	17	2.2
Lamiaceae	1	2	1	0.1
Leguminosae	16	32	313	40.8
Loganiaceae	2	4	18	2.3
Meliaceae	3	6	76	9.9
Moraceae	1	2	4	0.5
Ochnaceae	2	4	27	3.5
Polygalaceae	1	2	9	1.2
Rubiaceae	2	4	15	2
Sapotaceae	1	2	61	7.9
Simaroubaceae	1	2	14	1.8
Sterculiaceae	1	2	9	1.2
Tiliaceae	1	2	13	1.7
	50	100	768	100.1

TABLE 3. Families of shrubs identified with their respective species richness and relative abundances in the Damongo Scarp.

Shrub Family	Species Richness	Relative Species Richness	Abundance	Relative Abundance
Annonaceae	1	9.1	29	26.1
Celastraceae	1	9.1	6	5.4
Combretaceae	1	9.1	9	8.1
Euphorbiaceae	1	9.1	2	1.8
Leguminosae	1	9.1	10	9
Olacaceae	1	9.1	3	2.7
Rhamnaceae	1	9.1	3	2.7
Rubiaceae	4	36.4	49	44
	11	100.1	111	99.8

The five most abundant tree species in the scarp, contributing about 32% of total individual trees, were *Vitellaria paradoxa, Burkea africana, Detarium microcarpum, Terminalia avicennioides,* and *Daniella oliveri,* in decreasing order of abundance. In contrast, the least abundant were *Mitragyna inermis, Hexalobus monopelalus, Combretum collinum, Kigelia africana, Monotes kerstingii,* and *Vitex doniana,* representing 2% of the total number of individual trees recorded. The density of woody tree species was determined to be 69.3 trees per 100 m^2.

Shrub species richness and abundance.—A total of 185 individual shrubs belonging to 8 families, 10 genera and 11 species was recorded. The shrub family Rubiaceae recorded the highest number with 4 species, representing 36% (Table 3). The remaining plant families—Annonaceae, Celastraceae, Combretaceae, Euphorbiaceae, Leguminosae, Olacaceae, and Rhamnaceae—all recorded just one species each. The most abundant shrub species in the reserve were *Annona senegalensis, Gardenia aqualla*, and *Nauclea latifolia* contributing about 60% of the total number of shrubs identified. In contrast, the least abundant species were *Ximenia americana, Ziziphus mauritiana, Nauclea diderrichii,* and *Macaranga barteri,* representing about 10% of the total species recorded. The density of woody shrub species calculated per 100 m^2 was 18.5.

Regeneration status of trees in Damongo Scarp.—The regeneration study revealed a total of 39 tree species in all sampling sites, representing 18 families. The diameter class 0–4.99 cm (56.6%) was highest with 392 individuals, followed by the diameter class 5–9.99 cm (22.9%) with 159 trees, and lastly, big trees 10 cm and above (20.50%) had 142 trees. This indicates that the majority of individual trees were regenerating trees (56.6%) as illustrated in Figure 3.

DISCUSSION

Trees and shrubs which are widely distributed in the area constitute an integral component of the Damongo Scarp (Fig. 4). The species identified at the Damongo Scarp are similar to those reported in other guinea savanna areas of Ghana (Lawson et al. 1969; Hall 1976; Schitt & Adu-Nsiah 1993; Houssain & Hall 1996; Oteng-Yeboah 1996; Asase & Oteng Yeboah 2007; Asase et al. 2009). However, *Belanities aegyptiaca,* a common woody species recorded in surrounding areas of the guinea savanna, was not recorded in this study. Some species like *Rourea coccinea, Dalbergia afzeliana,* and *Hoslundia opposita*, recorded by Asase et al. (2009) but not in other savanna areas, were also not found in this study.

In a study of woody plant composition in a tropical savanna in northern Ghana, Asase et al. (2009) noted 43 species belonging to 13 families. Bright (2007), in a study of gradation in density of woody species around Lake Taakor in Tolon-Kumbungu in northern Ghana, recorded 47 species belonging to 22 families. Also Yahaya (2007) recorded 46 tree species belonging to 20 families. Schitt and Adu-Nsiah (1993) recorded a very high number (148) of tree species at the Mole National Park, Damongo (MNP), while Houssain and Hall (1996) reported a lower number (90) of tree species in the same MNP. Though most of the species recorded in this current study were recorded in all the above studies, a few different species (22%) were also recorded. This indicates that floristic composition of savanna is variable, even over relatively homogenous areas (Hopkins 1979; Lawson 1985).

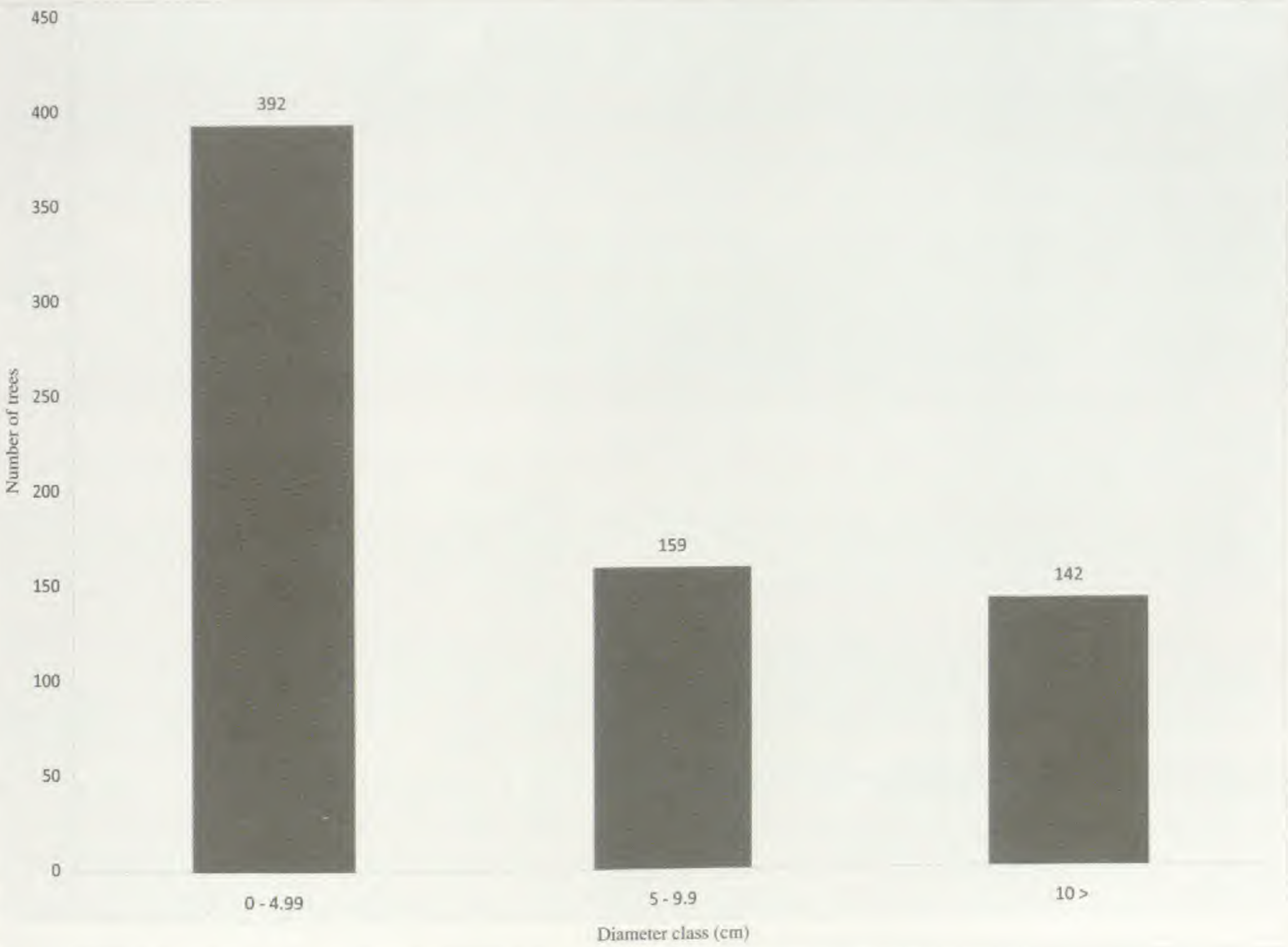

Fig. 3. Distribution of trees in the various diameter classes in the Damongo Scarp sample.

The high species richness and abundance of tree families such as Leguminosae (formerly Fabaceae) and Combretaceae in the guinea savanna have been noted elsewhere (Hopkins 1979; Asase & Oteng-Yeboah 2007; Asase et al. 2009). In a study of three traditional groves in northern Ghana, Oteng-Yeboah (1996) also reported the predominance of the family Leguminosae (Caesalpinaceae, Papilionaceae, and Mimosaceae) and Combretaceae in the different groves which is similar to the results of this study. The families Leguminosae (Mimosaceae and Caesalpinaceae) and Combretaceae, found to be dominant in this study, were also common among the dominant families reported by Bright (2007) and Yahaya (2007). However, Meliaceae, though reported as dominant in this study, was not a dominant family in the other studies. Hence, the same families may run through the various guinea savanna zones of northern Ghana but some may be dominant whereas others may not. Interestingly, some families (Sapotaceae and Bombacaceae) with few species recorded very high abundances; it follows that not all the families with many species are abundant (Asase et al. 2009) in the scarp.

It was observed that important economic trees such as *Vitellaria paradoxa* (Shea) and *Parkia biglobosa* (Dawadawa) were among the dominant species in the reserve, which conforms with the suggestion of Yaro (2008) that savanna vegetation of Ghana provides ecological conditions for economic trees such as Shea and Dawadawa. Apart from *Azadirachta indica* and *Acacia* spp., which were exotic savanna species, all the other species observed were native savanna species. The savanna vegetation is generally under threat from bushfires (Abatania &Albert 1993; Gordon & Ametekpor 1999) and grazing animals (Winter 1991; Smith & Franks 2000) which promotes the spread of weeds. Four woody species (*Afzelia Africana, Lophira alata, Nauclea diderrichii*, and *Vitellaria paradoxa*) are stated as vulnerable in the IUCN red list of threatened species (IUCN 2012).

The DBH class 0–4.99 cm recorded the highest percentage (56.6%) of the total individual tree species, indicating that most of the plant species were in the regenerating stage. Although Asase et al. (2009) reported

Fig. 4. Photographs of two sample plots showing the trees and shrubs on the Damongo Scarp.

big trees as being dominant in their study, this result is an indication of a secondary forest defined by Chokkalingam and DeJong (2001) as forests regenerating largely through natural processes after significant human and/or natural disturbance of the original forest vegetation.

The shrub species identified on the scarp are among the species that have been reported in guinea savanna areas of Ghana (Lawson et al 1969; Hall 1976; Schitt & Adu-Nsiah 1993; Oteng-Yeboah 1996; Asase & Oteng Yeboah 2007; Yahaya 2007; Asase et al. 2009). A total of 11 shrub species belonging to 8 different families were recorded in the scarp. Schitt and Adu-Nsiah (1993) reported 61 shrub species while Asase et al. (2009) recorded 19 species belonging to 8 different plant families elsewhere in guinea savanna of Northern Ghana and Yahaya (2007) recorded 15 species belonging to 11 families.

The results suggest that generally guinea savanna zones of Ghana are less rich in savanna shrubs. Five families—Euphorbiaceae, Annonaceae, Celastraceae, Rubiaceae, and Fabaceae (now Leguminosae), reported by Asase et al. (2009)—were also found in this study, with Rubiaceae being the species rich family. Yahaya (2007) recorded 15 shrub species belonging to 11 families, with Rubiaceae being the species rich family. Similarly Bright (2007) identified 8 shrub species belonging to 5 plant families, with Rubiaceae the dominant family. Comparatively the shrub species recorded in this study was either higher or lower than the above mentioned studies, however, Rubiaceae was commonly the dominant family throughout the studies. This indicates that Rubiaceae may be the family with the largest number of shrub species in the guinea savanna zone of Northern Ghana. The abundance of two species recorded, *Annona senegalensis* and *Gardenia aqualla* in the reserve, confirms their frequent occurrence in the study area, as also reported previously by Schitt and Adu-Nsiah (1993).

Densities of 69.3 trees per 100 m^2 and 18.5 shrubs per 100 m^2 were recorded in the scarp. Tom-Dery and Schroeder (2011) stated this method of estimating density as being systematically incorrect, but used it to compare survey results with those of other authors in Ghana, and it is herein used for such comparative purposes. Yahaya (2007) recorded a density of 39 trees per 100 m^2 and 8 shrubs per 100 m^2 similar to Asase et al. (2009) who also recorded a density of 39 trees per 100 m^2 and 15.4 shrubs per 100 m^2. The higher density of trees than shrubs recorded in this study compared to the two previous studies, suggests that densities of trees are far higher than shrubs in guinea savanna areas which implies that more tree species are widely distributed in the savanna areas than shrubs. This further implies that savanna areas are richer in trees than shrubs. This finding confirms the report of Cole (1986) and Stott (1991) that in savannas, tree densities are higher.

To conclude, the study is the first work on the woody species abundance and species richness in the Damongo Scarp. The assessment has revealed that the characteristics of the vegetation in the scarp were generally similar to those of other guinea savanna areas. It has also revealed that the floristic composition (species richness) and abundance of woody species in different areas of the guinea savanna zone are unique. It is therefore vital to study the diversity of plants found in the different areas of the guinea savanna zone of Ghana to effectively conserve the botanical resources of the different areas, especially unique land masses such as the Damongo Scarp.

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